AQUARIUS/SAC-D

Aquarius Mission Operations Anomaly Reporting and Resolution Process

Aquarius Project Document: **AQ- 2510-0007**

Date: November 7, 2011

Release Initial

NASA CONAE

AQUARIUS/SAC-D

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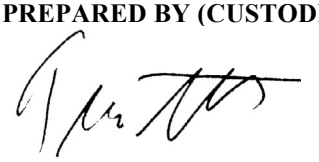

7 NOVEMBER 2011

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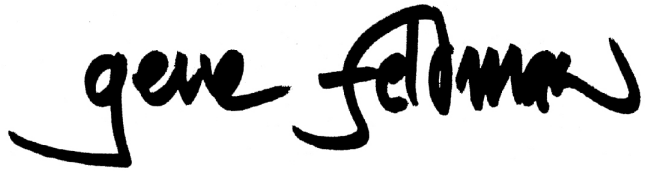

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Aquarius Mission Operations Anomaly Reporting and Resolution Process (AQ-2510-0007)					
Signatory	Request Sent	Signature Rcvd	Sign off Date	Comments	Comments Integrated in Version
Gene Feldman	7-Nov-11	**APPROVE**	7-Nov-11	Previous version approved.	
Fred Patt	7-Nov-11	**APPROVE**	7-Nov-11	Previous version approved.	
Simon Collins	7-Nov-11	**APPROVE**	7-Nov-11	Comments for immediate inclusion given to author (F. Patt)	Draft 5.2
Gary Lagerloef	7-Nov-11	**APPROVE**	7-Nov-11		
Dankai Liu	7-Nov-11	**APPROVE**	7-Nov-11	Comments for immediate inclusion given to author (F. Patt)	Draft 5.1

DOCUMENT CHANGE LOG

Change Number	Change Date	Pages Affected	Changes/ Notes	General Comments
-	7 November 2011	All	Initial Release	

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1.0 Introduction

1.1 Scope

This document defines the processes for Anomaly Reporting and Resolution as it applies to the Aquarius instrument of the Aquarius/SAC-D project. The process for SAC-D service platform and instrument anomalies and CONAE ground segment (GS) anomalies is addressed in the SAC-D Mission Operations Anomaly Reporting and Resolution Process.

1.2 Applicability

The Aquarius Operations Team (AOT) and the Aquarius Instrument Team (AIT) are responsible for implementing this document pertaining to the Aquarius Project. The process specified in this document applies to anomalies occurring during the operation of the Aquarius instrument.

1.3 Applicable Documents

- L3 Aquarius Ground System and Test Requirements, AQ-326-0152
- Aquarius Science Team to Ground System ICD, AQ-336-0243
- Aquarius Ground System - Aquarius Instrument Team Anomaly ICD, AQ-336-0522
- SAC-D Mission Operations Anomaly Reporting and Resolution Process, GS-OIV-PAS-ME-00100-A
- Aquarius Instrument Technical Documentation, 334-SAC-20111020-011
- ACCS Command Planning Procedure, AQ-002-PS-0002
- ACCS Data Monitoring Procedure, AQ-002-PS-0003
- ACCS Configuration Control Procedure, AQ-002-PS-0001
- The online Trac User's Guide: http://aquarius.gsfc.nasa.gov/AQOPS/wiki/TracGuide

2.0 Overview

This section provides an overview of the anomaly detection process, the roles and responsibilities of the organizations involved and the facilities and systems to be utilized.

2.1 Anomaly Detection Overview

During the operations phase of the mission, it is expected that most anomalies will be detected by the routine monitoring described in the Aquarius Data Monitoring Procedure. A major component of this procedure is the automated housekeeping telemetry (HKT) conversion and limit checking that will be performed on the incoming Aquarius and SAC-D data by the Aquarius Command and Control System (ACCS) analysis tool and displayed on the ACCS web site. The Aquarius instrument limits have been specified by the AIT and implemented by the AOT. Limit violations that continue for a specified time (nominally 1 minute) will cause an alert to be issued to the members of the AOT and AIT.

Following an alert, the teams will perform an initial assessment of the event that triggered the alert, to determine whether it constitutes an anomaly. Some planned events (e.g., orbit adjust and cold sky calibration maneuvers) will cause alerts, and these require only a review of the affected HKT values to assure that they have returned to the normal range. For non-planned alerts, the AIT and AOT will communicate informally on the review of the HKT and their findings.

Once it is determined that the alert may constitute an anomaly, the most knowledgeable team (most likely the AIT) will initiate an anomaly report as described below. The AIT will be the lead team for all Aquarius instrument anomaly investigation, response and resolution.

If the anomaly involves the SAC-D service platform, the initial detection may be performed by either CONAE or the AOT. As for Aquarius, the teams will initially communicate informally to determine whether the event constitutes an anomaly before an anomaly report is initiated.

2.2 Roles and Responsibilities

The organizations involved in Aquarius anomaly reporting and resolution are:

- The AOT at the Goddard Space Flight Center (GSFC).
- The AIT at the Jet Propulsion Laboratory (JPL) and GSFC.
- The SAC-D Flight Operations Team (FOT) at CONAE.
- The Science Operations Control Board (SOCB).

The roles and responsibilities of each of these organizations for anomaly reporting and resolution are described below.

2.2.1 Aquarius Operations Team

The AOT is responsible for all routine operations of the Aquarius instrument. For anomalies, this includes:

- Routine monitoring of the Aquarius housekeeping telemetry (HKT) and science data that may indicate an anomaly, as described in the ACCS Data Monitoring Procedure.
- Reporting to the AIT of suspected anomalies detected through monitoring.
- Initiating and updating anomaly reports.
- Responsibility for investigating and responding to Aquarius GS anomalies.
- Supporting the AIT in the anomaly investigation.
- Generation of command plans and requests as directed by the AIT.
- Configuration management (CM) in the ACCS of updated operational configuration items (CIs), e.g., command database, scripts, telemetry conversions and limits delivered by the AIT, as described in the ACCS Configuration Control Procedure.
- Management of the anomaly reporting and tracking system (described below).

The AOT is led by the Aquarius Mission Manager.

2.2.2 Aquarius Instrument Team

The AIT is the lead organization for investigation and developing the response to all Aquarius instrument anomalies, including:

- Reporting to the AOT of suspected anomalies detected through independent monitoring of the instrument.
- Initiating and updating anomaly reports.
- Overall responsibility for investigating and responding to instrument anomalies.
- Presentation of the anomaly investigation results and resolution plan to the SOCB.
- Directing the implementation of the anomaly response plan, including the support by the AOT and the FOT.
- Configuration management of updated Aquarius CIs in the JPL CM system.
- Management of the anomaly reporting and investigation using the JPL PFR tool.

The support provided by the AIT is coordinated by the Aquarius Instrument Manager.

2.2.3 Flight Operations Team

The FOT is responsible for all observatory operations. For anomalies, this includes:

- Monitoring of SAC-D HKT and any Aquarius HKT fields requested by the AIT.
- Reporting anomalies to the AOT.

- Overall responsibility for investigating and responding to SAC-D and CONAE GS anomalies.
- Implementing Aquarius command requests from the AOT during anomalies.
- Scheduling additional NEN coverage during anomaly investigations.
- Managing and reporting of SAC-D and CONAE GS anomalies according to the SAC-D Mission Operations Anomaly Reporting and Resolution Process.

The FOT is directed by the SAC-D Mission Operations Manager.

2.2.4 Science Operations Control Board

The SOCB is responsible for overseeing the anomaly resolution process. It consists of the following members:

- Aquarius Principal Investigator (PI)
- Aquarius Deputy PI
- Aquarius Mission Manager
- Aquarius Ground System Engineer
- Aquarius Science and Operations Support Lead
- Aquarius Instrument Scientist
- Aquarius Instrument Manager

The SOCB is chaired by the Aquarius PI. The responsibilities of the SOCB for Aquarius anomalies are:

- Assigning the final criticality rating for the anomaly as described below.
- Reviewing and approving the anomaly response plan developed by the AIT or the FOT.
- Oversee the analysis of the science impact of anomalies and any required instrument or service platform configuration changes
- Approving the final anomaly resolution.

2.3 Facilities and Systems

The specific facilities and systems to be used for Aquarius anomaly support are described below. This does not include a complete description of the general Aquarius and SAC-D support facilities and systems at GSFC, JPL and CONAE, which are described in the applicable documents and elsewhere.

2.3.1 Trac Reporting and Tracking System

The AOT operates and maintains the Trac open-source reporting and tracking system, for reporting and documenting anomalies, their cause, and the corrective action taken. Trac is electronically accessible via the Internet: http://aquarius.gsfc.nasa.gov/AQOPS/ to all Aquarius organizations involved in Phase E operations, including the AOT, the AIT, the SOCB, and the Science Team. For compliance with ITAR and Project organizations TAAs, information will be exchanged with CONAE by other means (e.g., E-mail),

2.3.2 JPL Problem Reporting System

All Aquarius anomalies that are investigated by the AIT and determined to be in-flight hardware/software design problems or failures will also be reported and tracked in the JPL Problem Reporting System (PRS). The AIT will provide summary status reports and resolution summaries of the problems which will be attached to the corresponding Trac tickets.

2.3.3 Aquarius Instrument Testbed

The AIT will maintain the Aquarius instrument testbed at JPL and will utilize it for investigating anomalies and testing response plans (e.g., updated command scripts or software package).

2.3.4 CONAE Flight Anomaly Reporting System

The SAC-D FOT will use the GS Operations Assurance Reporting System (GSOARS) for reporting and tracking service platform and CONAE GS anomalies, as described in the SAC-D Mission Operations Anomaly Reporting and Resolution Process.

2.3.5 SAC-D Engineering Model

CONAE will maintain the SAC-D Engineering Model (EM) at the Cordoba ETC ground station. The EM will be used by the FOT for testing service platform anomaly responses, and jointly by the FOT, the AIT and the AOT for testing Aquarius commanding required for instrument

3.0 Anomaly Reporting and Resolution Process

The following sections describe the processes for anomaly reporting, assignment, criticality code determination, review, approval and closure. A summary of the information flow among the organizations is shown in Figure 1. A step-by-step description of the anomaly process flow is provided in Appendix A.

3.1 Anomaly Reporting

An anomaly report will be written for any unexpected event or problem detected during the Aquarius operations. All Aquarius anomaly reports will be initiated in Trac. The organization that first detects the anomaly – either the AOT or the AIT -- will be responsible for entering the anomaly report in Trac. An anomaly that is reported by CONAE will be entered in Trac by the AOT. The anomaly may include one or more of the following:

- An incident, real or suspected, that indicates an anomaly in the Aquarius instrument hardware and/or software.
- A SAC-D service platform incident or issue that affects Aquarius commanding or data quality.
- An Aquarius or SAC-D GS issue that impacts the command and control of the Aquarius instrument, or results in unplanned science data loss or degradation.

The initiator will provide sufficient information to summarize the known information about the anomaly. The specific information to be provided will vary according to the nature of the anomaly, but would normally include the associated time or time range, the systems or subsystems (if known) that are suspected, and an estimate of the impact. The initiator is not necessarily responsible for evaluation of the anomaly or for assigning the criticality code. All incidents will be documented within one working day following the incident or observation. The Trac ticket will automatically notify the AIT and the SOCB by E-mail

The AOT and the AIT have the joint responsibility of determining if a given anomaly involves or affects the Aquarius instrument. Anomalies that are suspected to result from an instrument hardware or software problem will require AIT investigation and, once determined to be an in-flight hardware/software design problem or failure, will require opening a PFR in the JPL PRS that will be used to document, track and resolve the instrument problem.

An anomaly that is believed to involve the SAC-D service platform or the CONAE GS will be reported to CONAE for entry into the GSOARS. This will be performed by sending an E-mail of the report to: gsoa@conae.gov.ar. For compliance with ITAR and Project organizations TAAs, information provided in the anomaly summary will not contain export-controlled information.

3.2 Anomaly Assignment

As soon as detected, any pre-approved, emergency contingency plan, if appropriate to protect the instrument, should be executed to ensure instrument hardware is not damaged. If the anomaly affects the instrument, the Aquarius Instrument Manager at JPL will assign an AIT lead and other team members to investigate of the cause and impacts on the Aquarius instrument. The first responsibility of the AIT is to ensure that the instrument is safe and report to the SOCB an initial criticality rating within one working day of the reported incident.

The assigned AIT members will investigate the problem and/or impacts on the instrument operations and determine the necessary contingency operations to resume nominal or continued operations and assess any residual limitations for future operations. The AIT lead will complete the PFR responses in the JPL PFR tool and provide summary and status of the investigation in the GSFC Trac tool.

For any anomaly, the assigned AIT lead is responsible for providing anomaly resolution progress reports, impacts assessments and final resolution reports using Trac. All updates will be copied to the AOT, the AIT, and the SOCB. (For instrument anomalies, this is in addition to detailed information for the anomaly and its resolution to be supplied in the PFR.)

3.3 Criticality Codes

The Science Operations Control Board is responsible for the final assignment of the criticality rating of an anomaly. This will normally be performed after the initial investigation of the anomaly by the responsible engineer. The following is the criteria for criticality rating to be used by the Aquarius project.

Criticality 1 – Represent high risk to achieving full mission success

- Safety of personnel and hardware
- Loss of capability to conduct essential Mission Operations functions
- Permanent loss of essential mission data
- Loss of capability to accomplish essential commanding
- Loss of a major spacecraft or payload function

Criticality 2 – Represents significant risk to achieving full mission success

- Significant delays in scheduled mission events
- Significant loss of mission data
- Significant impact from delays in acquisition of mission data
- Significant impact from delays in the command process
- Loss of a minor spacecraft or payload function

Criticality 3 – Represents no significant risk to achieving full mission success

- Negligible delays in scheduled mission events
- Negligible loss of mission data
- Negligible impact from delays in acquisition of mission data
- Negligible impact on the commanding process
- Negligible impact on the spacecraft or payload function capability

Criticality 4 – Represents no risk to achieving full mission success

The final criticality rating will be entered into the anomaly Trac ticket after it is assigned.

3.4 Review, Approval and Closure

The review / approval / closure process, performed by the SOCB, shall consider the following issues:

- The analysis addresses the problem.
- The anomaly response plan addresses the analysis and the problem.
- The response plan has been approved and implemented.
- The risks have been assessed, documented in the report, and accepted by the project.
- All updates to Aquarius CIs have been approved and placed under CM.

- The success of the response plan has been verified and documented.

3.4.1 Review and Approval

The responsible engineer will present the anomaly response plan to the SOCB for approval prior to implementation. If the plan involves CONAE and the SAC-D service platform (e.g., non-nominal commanding), the plan will also require approval by the SAC-D Mission Operations Manager. The approvals for the response plan will be entered in Trac.

3.4.2 Configuration Management

The AOT will maintain all Aquarius operational CIs under CM as described in the ACCS Configuration Control Procedure. However, to facilitate the timely investigation and response to anomalies, the AIT will also maintain all instrument configuration items under CM at JPL. As described in the Aquarius Instrument Technical Documentation memorandum , the AIT will update their copy of the CIs as needed to implement the anomaly response plan, and then deliver the updated CIs to the AOT.

3.4.3 Closure of an Anomaly Report

The closure of an Aquarius Anomaly Report requires the approval of the following:

- Lead engineer for the anomaly response
- SOCB (represented by the Aquarius PI or his designate)
- SAC-D Mission Operations Manager (for an anomaly involving CONAE)

The approvals are provided and communicated to the team via Trac ticket updates.

For any Aquarius anomaly that resulted in a PFR in the JPL PRS, the PFR will be closed prior to closure of the Trac ticket. Likewise, for any SAC-D or CONAE GS anomaly, the anomaly report in GSOARS will be closed before the Trac ticket.

The Aquarius information flows for anomaly notification and resolution are given in Figure 1 that depicts the interfaces between the MOC, the AQ GS and the JPL Sustaining Engineering and Operations (JPL SE&O).

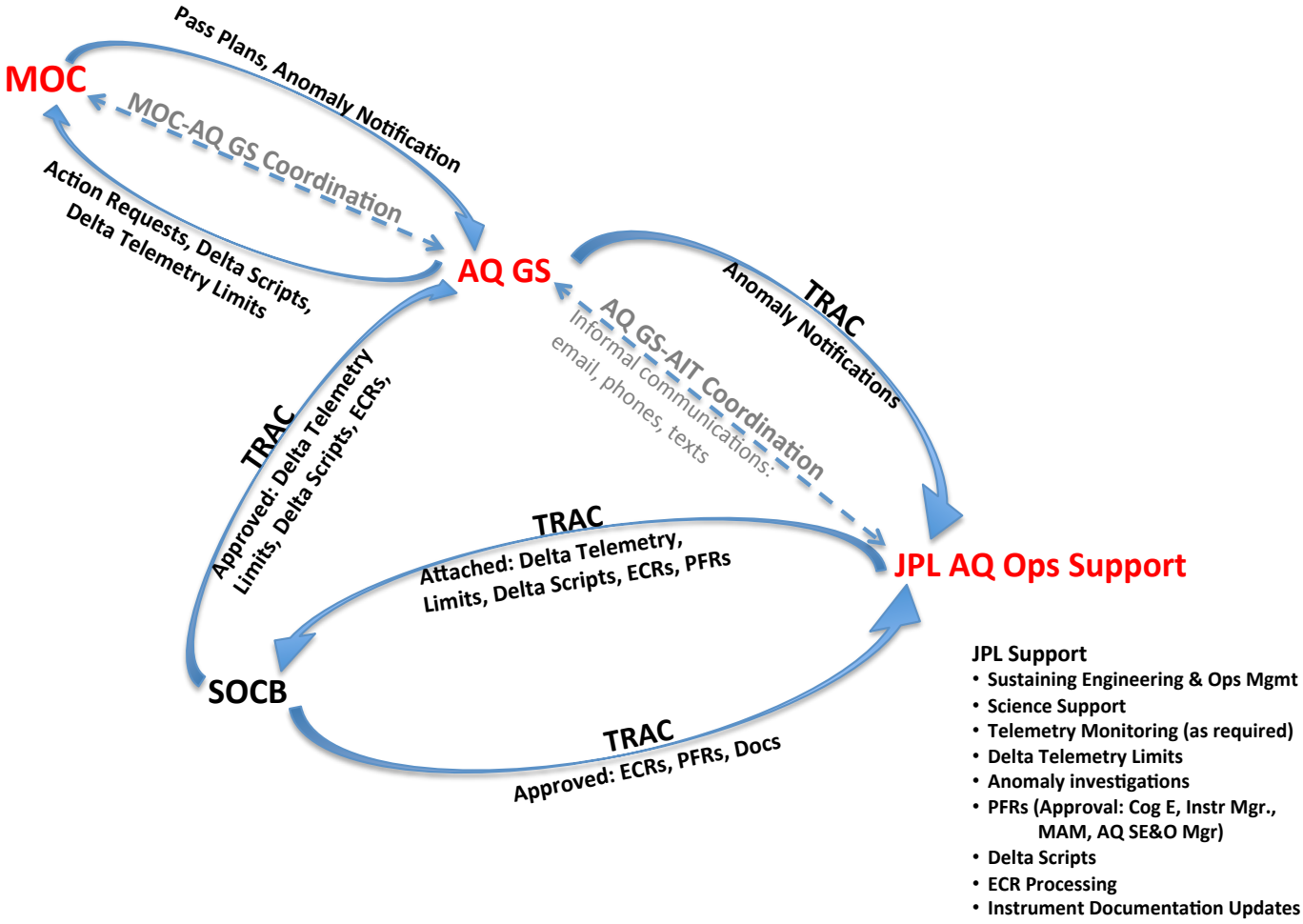

Figure 1 Aquarius Anomaly Information Flows

Appendix A Aquarius Anomaly Process Flow Description

I. Discovery
   a. Aquarius and SAC-D operations teams detects a potential mission anomaly either in real time or non-real time on-board the flight system or in the ground systems.
   b. If the anomaly occurred on the flight system, the ops teams needs to note any autonomous onboard response of the flight system and the resultant state of the flight system.

II. Notification
   a. If detected by the SAC-D Flight Operations Team (FOT), they notify the Aquarius Operations Team (AOT) of the anomaly by E-mail.
   b. If anyone on the Aquarius Project teams detects an anomaly, they will notify the AOT and the Aquarius Instrument Team (AIT) by E-mail.
   c. In either case, the AOT and AIT will jointly determine whether the detected event constitutes an anomaly. The cognizant organization generates a preliminary anomaly report within the Trac tool, which is copied to the Aquarius Science Operations Control Board (SOCB) and the JPL Science and Operations Support Manager.

III. Assign Anomaly Lead and investigative team
   a. The Aquarius Mission Manager (MM) identifies an AOT anomaly lead to work with the Aquarius Project team responsible for resolving the anomaly (AIT or AOT)
   b. For instrument anomalies, the resolution is the responsibility of the AIT. An anomaly that impacts multiple Aquarius areas may have multiple sub-leads. Once the anomaly is determined to be an in-flight hardware/software design problem or failure, the AIT will open a JPL PFR, and its number will be entered reference in the Trac anomaly report. Upon request, the AIT can provide detailed reporting on the status of instrument anomalies as captured in the JPL PFR system.
   c. If resources are required above the nominal allocation of the responsible team, the AQ MM and the AQ PI will authorize additional support.
   d. For SAC-D anomalies that may impact Aquarius objectives or require safing or recovery of instrument functionalities, the AIT will coordinate with the AOT and SAC-D FOT for anomaly investigation, recovery procedures and verification. The JPL Instrument Manager will select AIT members to support the anomaly recovery efforts.
   e. The Aquarius Instrument Manager (IM) is responsible for managing AIT resources and the efforts for anomaly recovery. If additional JPL resources are needed outside of the AIT, the IM will coordinate this with the Aquarius Science and Operation Support Lead for JPL.

IV. Develop Anomaly Solution
   a. The responsible anomaly team coordinates within and outside their organizations to develop recovery and verification plans. Status reports inserted into the Trac tool.
   b. If the anomaly affects the Aquarius instrument, the AIT will develop commands and instrument operations procedures to resolve the anomaly. The AIT plans recovery commands and will verify instrument recovery commands and sequence on the Aquarius Testbed.
   c. GS anomalies, not involving the instrument, are planned and verified by the AOT and the FOT.

V. Obtain Approvals
   a. When the responsible team is ready with a recovery plan, notification will go out to the SOCB via Trac, with an anomaly status noted as “solution proposed.”
   b. The proposed solution is reviewed by the SOCB and, if approved, be noted in Trac.

VI. Execute and Verify
   a. For instrument commands and associated Observatory actions, the AOT generates action requests, checks Aquarius command flight rules and submits these to the FOT for generation and EM verification.
   b. The SAC-D FOT exercises their pass plan generation procedure and verifies the recovery commands on the Observatory engineering model (EM). If the recovery fails on the EM, the anomaly recovery process reverts back to step IV.
   c. The SAC-D Mission Operations Manager approves the execution on the FM.
   d. The SAC-D FOT executes the recovery procedure on the FM, with oversight and monitoring by the AIT and support as needed by the AOT.
   e. The AIT verifies the resolution of the anomaly.

VII. Report
   a. The AOT or AIT updates Trac with final report and resolution status.
   b. The SOCB concurs with the anomaly resolution in Trac.
   c. For Aquarius instrument anomalies, the AIT will document and close out the JPL PFR and provide a copy to the AOT team lead.